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shirt and a kettle." One of them replies, "Yes, my sister's husband, that is good." The presents are made the next morning at daybreak. The elder brother-in-law takes the horse, and the next receives the other gifts. At noon the widower washes his face and seeks another wife.

In like manner when a woman loses her husband she must put earth on her face and fast during the day from sunrise to sunset for a year. She too can eat after sunset. At the end of the year she brings the gifts to the sister and younger brother of her husband. The sister gets the horse and the brother takes the rest.

When a widower does not make presents to the kinsmen of his deceased wife before marrying again, he is sure to provoke the anger of his brothers-in-law. Formerly an old man took a gun and shot at his sister's husband for this reason. And another man, when the Kansas were south of Council Grove, Kan., took a knife and gashed the head of the offending man in several places. Therefore widowers are accustomed to observe this rule of making presents, fearing the punishment which their offended affinities might inflict on them.

THE RELATIONS OF MIND AND MATTER.

BY CHARLES MORRIS.

(Continued from p. 542, June number.)

II. The Nervous Mechanism.

IN all the higher animals a system of fibers and cell masses forms the channel by which external energy enters the body, and is distributed to its every organ and tissue. There is considerable variation of form and condition in this apparatus, but it is essentially a single organic agent, and includes the muscles as part of its organism. There is little apparent differentiation in the fibers. The main differentiation is in the endings of these fibers. Of these endings a very great number exist on the surface of the body, where they are variously modified and adapted to different purposes. These are the receiving organs, through whose aid external energy reaches the conducting fibers. They are varied to receive every form of external energy. This energy beats upon the surface of the body in at least six forms or modes. One of these is that known as ethereal vibration, through which far distant objects make themselves felt. Part of these vibrations enter the body through a specially organized nerve apparatus, the rods and cones of the eye. But they all, as radiant heat, enter at every part of the surface, by aid of less specialized nerve endings. Heat in another condition, the static vibrations of contiguous matter, also enters at every part of the surface, presumably through the same channel. A second series of vibrations, those of ponderable matter, enter by the channel of the ear, through the aid of an intricately organized apparatus. In addition to these three conditions of vibratory influence there are three modes of direct contact through which motor energy also makes its way into the body. These are solid, liquid and gaseous contact. Gaseous contact enters by a special channel, that of the nerves of smell, which are excited by the touch of excessively fine material borne on the air current. Liquid contact finds its special channel in the nerves of taste, which are only sensitive to the direct touch of liquified or dissolved matter. Solid contact has the whole surface for its field. The nerves of touch, indeed, are also sensitive to liquid and gaseous contact if exerted by matter in motion, but mainly respond to the contact and pressure of solid matter.

The internal extremities of the nerves lack the variety of their surface endings. They are distributing organs as the latter are receiving organs. The energy received varies greatly in character, and needs considerably varied apparatus for its reception. That distributed has become far more homogeneous and can be dispersed by a single apparatus. This is the muscle fiber, which, though not ordinarily considered so, is essentially but a nerve ending, an aggregation of unstable chemical molecules around the extremity of a nerve. And the combined aggregates of these fibers, which constitute a muscle, are but a mass of nerve extremities ending in matter which is adapted to set free a considerable volume of motor energy.[1] Into this matter the energy which has traversed the nerves is discharged, and there instigates an active chemical change and a rapid freeing of energy, with animal motion as its result.

Such is reflex action, a frequent mode of nerve action in man, and possibly the only one in many of the lower animals. Motor energy differing greatly in character and source is thus forced to produce a single effect, that of muscular contraction and animal mass motion. But in all the higher animals other effects are produced. All the nerve fibers enter cells or masses of cells called ganglia, though there is no evidence that they end there. There is some reason to believe that they simply pass through these cells, with a reduction of diameter, and perhaps a division into branches. All we can be sure of is that the motor energy which they carry inward does not all pass through these ganglia, but that much of it is arrested in its course and there distributed. And in this distribution an interesting feature of the case is, at least so far as the cerebral ganglion is concerned, that the motor energy retains the peculiarities it possessed before entering the body, or something equivalent to them, and impresses a permanent record of each such peculiarity upon some internal tablet. Only when this energy continues its course over the nerves to the muscles does it lose its individuality and merge in the general outflow of muscle energy.

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[1] See Organic Physics, AMER. NAT., Feb., 1883.

As we descend in the animal kingdom it is to find this complex apparatus of sensation and motion gradually simplify. The sensory nerve-endings and their organs grow less intricate, and their susceptibility is diminished. Some of the organs of special sense completely disappear, and the power of the others becomes little more than a modified touch. In very many cases the body is covered by a rigid armor, and the influence of external energy is limited to a small region of the surface. Finally the special senses disappear, apparently the last to vanish being that of sight, which is reduced to a vague discrimination between light and shade. The cerebral ganglion grows less and less marked, and disappears as a special organ. Finally the nerve and muscle fibers vanish, one of their last traces being the single cell which, in the Hydra, appears to function both as nerve and muscle. On reaching the Protozoa we find forms quite destitute of sensory and motor organs. And yet sensation and motion persist. These powers seem to be native to protoplasmic matter, however aggregated, and are displayed even in the plant cell wherever it is so situated that its protoplasm is exposed to external energy.

Yet late discoveries in regard to the constitution of the cell prove it to be by no means the simple homogeneous structure formerly supposed. The division into nucleus and outer cell has been traced to a very low level, and perhaps exists at the lowest level. And the nucleus, and to a less marked extent the outer cell, are now known to be heterogeneous in structure, composed of at least two distinct substances, one of which exists as very minute fibrils, of which the other occupies the interspaces. This organization, very well marked in the cells of the higher animals, becomes much less so in the Protozoa, and is only clearly distinguishable in their higher representatives. Yet this is probably due to the imperfection of instruments and methods. The nervous structure has been only recently discovered in the Medusæ, and has not yet been traced in the stem of the compound Cœlenterates, though this conveys sensory impulses, and doubtless contains communicating fibrillæ. In like manner the fibrillar structure may exist in all cells, though not always sufficiently defined to be discoverable.

Again the cilia, so common in the single-celled life forms and in many of the surface cells of higher animals, have been traced in some instances into direct connection with the fibrillæ. Perhaps in all cases they are external continuations of the fibrillæ, and may thus function as the primitive nerve-ending, the sensory termination which receives impressions of external motor energy and transmits it to the fibrillæ to be distributed throughout the substance of the cell. There is thus some reason to believe that the developed motor apparatus of the highest animal has its primitive counterpart in every cell, and that the unfolded nervous and muscular organism of man is but a direct development of that existing in the Infusoria. In Amœba the pseudopod may function as a sensory organ and receive motor impressions which are distributed throughout the cell mass. Tissue contraction seems to be the general result of such motor influence, however received and distributed.

Late research indicates the method of development of this primary motor apparatus. It has been clearly shown that fine threads of protoplasm connect contiguous cells in frequent instances. Observers have seen this structure in the cells of numerous species of plants, and some writers look upon it as universal in plant cells. In addition to the protoplasmic threads which join the nucleus to the cell wall, others pass through the wall, probably through minute apertures, and connect with the protoplasm of one or more neighboring cells. Possibly this may be a result of cell division. When one cell separates into two its protoplasm may not completely separate. And it is quite conceivable that this net work of protoplasm, which connects all the cells of many and possibly the active cells of all plants, may have a nervous function, though the conditions of plant life are such as seldom to call it into exercise.

In animals a similar structure has been observed in many cases, and particularly between epithelial cells, where it is most likely to be called into functional activity. Some observers claim that it is general, and that the animal body is an intricate net work of fibrillæ, of which the cells forms the nodes. This doctrine, though it has been strongly combatted, is certainly not without considerable support in observation, and there is good reason to believe that such continuity of protoplasm exists between the cells of at least several of the animal tissues.

Thus the primitive motor organism quite probably exists with little change throughout the highest animals, and may serve to bring every cell within the reach of motor influences, as the similarly minute vascular structure has a like result in regard to nutritive influences. The conditions here indicated, however, exist in very different degrees of perfection in different cells. In some tissues they may almost or quite have ceased to exist through lack of exercise. In nerve tissue, on the contrary, they are remarkably well developed. The large nerve cells of the ganglia possess an intricate fibrillar structure, so distinctly developed that it was clearly recognized long before any one imagined that such a structure was a common feature of cells. And the extrusion of protoplasmic threads through the cell walls, in direct continuation of the internal fibrils, is equally well marked. The whole surface of some of the cells is covered with a series of fine nerve rootlets. Yet greatly developed as this structure is, there is no reason to doubt that it is a direct unfoldment of the general cell structure, with its nuclear and outer cell fibrils and its one or more protoplasmic threads running to neighboring cells. In the case of nerve tissue the rootlets also connect with other cells, but the connected cells are often separated by very considerable intervals. Very likely this separation is a result of natural selection. In original Metazoa sensory impressions may have passed from cell to cell through the aid of their connecting protoplasmic threads. In forms in which no nerves can be discovered this method may still continue, as a slow yet sufficient process. But as animal life developed the connected cells seem to have become more and more widely separated, the fibril growing thicker and becoming a nerve fiber, with the power of conveying motor energy more rapidly and in greater quantity. Through some such process successive steps of evolution may have led to the condition now existing in the highest animals, with very numerous fibrils emanating from the cells, their combination into bundles with an insulating covering, and their final distribution to distant cells.

For this idea we have a degree of embryological warrant, and can trace the nerve organism to one of its ancestral stages. For, as observed by Beale, the cells from which the nervous system arises form processes which connect adjacent cells together. They are thus direct counterparts of many, and perhaps of all, tissue cells. As growth goes on these cells separate, while their connecting processes lengthen and form the axis cylinder of the nerve fiber. In this we seem to perceive the phylogenetic development of nerve tissue. Eventually, as some observers consider, one of these cells becomes a cell in a nerve ganglion, the other a peripheral end organ, their connecting process being lengthened out into a nerve fiber. That in this we have an exact representation of the mode of development of nerve tissue, however, is far from certain. If so we should find each nerve fiber proceeding directly from one to the other extremity without intermediate ganglia. The frequent existence of these ganglia leads to another conclusion, and indicates that the original development pursued another line, which has been slurred over in the rapidity of unfoldment like so many embryological characteristics. Various hypotheses of the mode of development of nerve tissue have been heretofore offered, the most notable being that of Herbert Spencer, but these are mainly philosophical. Still another may be offered which is in direct consonance with the recent discoveries in cell and tissue formation above described, and which future embryological research may fully substantiate.

The hypothesis which we propose is the following. We have seen some reason to believe that in single-celled animals the motor impressions received by the cilia or otherwise are distributed throughout the cell by the fibrillæ. This distribution is at first general, but in case of special motions may become special, certain fibrillæ becoming specially capacitated, through exercise in this function, to convey the current. In Metazoan animals the connecting threads of protoplasm between the cells are doubtless competent to convey motor impulses from cell to cell, and they very probably preceded the devel'opment of nerves as a sensory arrangement, permitting a slow and general transmission of motor influences to every part of the body. But if any particular motions became habitual, through natural selection, the sensory inflow must have become to some extent specialized, following certain channels of conduction more frequently than others. But nutrition always attends activity, and in these special lines the fibrils must have grown larger and more capable. If their labor still increased, a second change must have succeeded. The line of special conduction being mainly composed of cells, with short interconnecting fibrils, a modification necessarily took place in the cells also. If the outer threads had continuous fibrillar connection through the cells, which we have some warrant to assume, these cell fibrillæ must have grown larger and straighter as a result of extra nutrition and natural selection. They may, indeed, have exhausted the cell nutriment and caused the abortion of the remaining filaments. In short, a continuation of this process of evolution may have caused the gradual disappearance of most of the cells in the line of conduction, and the conversion of their fibrillæ into direct continuations of the developing nerve fiber.

The make-up of the axis cylinder of every nerve fiber is in strong corroboration of this idea. It is found to consist of numerous extremely delicate fibrillæ imbedded in a finely granulated substance. Nuclei are also found in it. Thus it is closely analogous to the cell in composition, and presents strong indications of originating in a connected line of cells. Another feature of the nerve fiber is an interesting confirmation of this. The medullary sheath seems but a special elongation of the outer layer of the cells. It does not exist in the primitive nerve, of which we have probably a survival in the nerves of the sympathetic system. It seems the result of a fuller development, yet the fatty and albuminous matters of which it consists are the substances which exists most abundantly in the outer cell layer. Conversion into fatty matter is a general characteristic of deteriorating cells. Thus every portion of the nerve fiber can be traced directly to the cell, with singularly little change, and there is certainly much reason to believe that nerve conduction is an outgrowth of a primitive connected-cell conduction. All these cells did not disappear or suffer conversion. Some were retained, perhaps as centers of distribution, by whose aid a single inflowing current could be sent off in several directions as a partial survival of the original general distribution. And significantly, near these cells the axis cylinder is naked. The cell matter has not been converted into a medullary sheath. Yet more significant indications of such an origin of the nerve system are seen in the *bipolar* nerve cells. In these a nerve fiber enters the cell on each side, and its fibrillated structure is clearly continuous with the fibrillæ of the cell. And in many cases the medulla of the fibers is continued over the cell. Such a cell, therefore, appears to be a survival of the primitive nerve, and indicates its origin, as above conjectured, from a line of cells with protoplasmic fibrillar connections.

There is one more point here to consider, that of the termini of the nerve fibers. It is quite probable that they never terminate in the ganglionic cells, not even in those of the cerebrum, but that they connect with the fibrillæ of these cells, which in their turn connect with outgoing fibers. Nor is it by any means sure that they have actual termini in the peripheral and muscular cells. Indications point to the contrary. In many cases they seem to pass continuously through these cells and rejoin the exterior nerve fibrils, or to end in a plexus whose fibrillæ are probably continuous. Thus in the highest development of nervous tissue there is singularly little change in structure from the condition of undifferentiated cell tissue.

We may look upon the function of the nerve fibers as simply conductive, though it is possible that they add to the strength of the motor current through chemical change which takes place in their tissue. What is the function of the nerve cells? Very probably their action resembles that of the electric resistance coil. In telegraphy by decreasing the diameter of the wire the passage of the current is resisted, and part of it loses its electric character. By suitable contrivances this checked current may be converted into heat, light, magnetism or other forms of force. In the nerve cells the minute fibrillæ over which the current must pass seem to have a similar function. Part of the motor energy is converted into some other form of force. It may become heat. It may outflow into the high-atomed muscle molecules and cause chemical change. Or it may assume some other condition, as it very evidently does in the cerebral cells. There are possibly no actual nerve termini anywhere within the body, but simply occasional resistance nodes, in some of which a single inflowing current may be divided between several outgoing channels, but in many or all of which the current is checked and partly converted into some other mode of motion.

It is not necessary here to go into any minute description of the nervous system. In man it is virtually double. In addition to the external sensory and motor system, there is a secondary system which is devoted to the needs of the digestive cavity and to other internal duties. These systems are similar in general make-up, consisting of ganglia and communicating fibers, which extend partly to muscles and partly to the epithelial layer. But they have marked differences. The sympathetic has no central ganglion answering to the cerebrum. Its operations are all performed without consciousness except through the occasional aid of its cerebral nerve connections. And in its nerve fibers the axis cylinder is destitute of a medullary sheath. Some writers consider that its operations may have been originally conscious and have become unconscious and simply reflex through incessant repetition. Yet this is very doubtful. It presents every appearance of being a survival of a primitive nerve condition, beyond which it has not greatly developed. Consciousness is a condition that must have been originally vague and generalized, and which but slowly grew specialized with the gradual centralization of the nervous system. We cannot imagine it as retrograding and disappearing in any developing nervous system. In fact, the system of intestinal nerves has never become centralized and definite. Such consciousness as it may possess retains its original vagueness. Its functional existence is perhaps as ancient as that of the external nerve system, but its development has been much slower. When the latter had advanced to the condition of distinct nerves and ganglia, the former yet remained in the primitive stage of cell conduction. The nerves of external sensation have gained an insulating sheath while those of intestinal sensation remain naked. The one has become definitely centralized while the other yet lacks special organization. These results flow from their difference of duties, which in the one case are simple and unvarying, in the other complex and excessively varied. As a result such consciousness as may exist in the intestinal system retains the dim vagueness which probably exists in animals of a very low grade. But in the cerebro-spinal system consciousness has become sharply centralized and defined. The peculiar condition which we call consciousness may have its roots very low down in the soil of nature as a highly generalized accompaniment of motor energy. In the evolution of higher forms and conditions it has grown steadily more specialized, until, in the central nerve organ of man, it has become a concentrated, developed and sharply defined condition, the necessary accompaniment of an equally special centralization of substance and energy, which we name the mind.

The cerebro-spinal nerve system in man and the higher animals has become a highly differentiated and complex organism, whose make-up may be very briefly described. The sensory nerves, which convey motor impressions from the various points of the surface, pass through a series of spinal ganglia in their upward journey toward the brain. Here they enter the great ganglia at the base of the brain, to which the nerves of some of the special senses pass directly. From here they communicate with the cerebrum, though whether directly or indirectly is not certain. It is certain that when the cerebrum is removed many of the sensory nerves are found to be in direct communication with those of motion. It is almost equally certain that in ordinary cases many sensory impressions are directly passed on to the motor nerves, with or without consciousness. These intermediate ganglia, then, may perform a special duty in the economy which we will consider further on. From the cerebrum motor nerves enter these ganglia, from which the same or other motor nerves emerge and pass onward, mainly by the route of the spinal ganglia, to the muscles.

According to M. Luys[1] the cerebral organ is composed of a vast array of fibers which diverge to enter a hemispherical sheet of gray or cellular nerve matter. This gray sheet is greatly wrinkled and folded so as considerably to increase its superficial extent. It is of no great thickness, and is composed of successive layers of nerve cells connected by fibers, these cells being smaller in the surface layers and growing larger in the deeper layers. The hemisphere is really a double mass, since it is divided in the middle line of the body, the two halves being connected by a thick commissure of nerve fibers. The cerebral cells are pyramidal in shape, the summit of the pyramid being directed upwards. Each of these cells gives off a delicate fringe of fibrils like the fine rootlets of a plant, which spread out in an interlaced network and form a continuous fine plexus. These fibrils are believed to be the origin of the sensory nerves, becoming aggregated and covered with a medullary sheath. In addition to the processes which thus break up into rootlets of protoplasm, there is always one at least which does not thus subdivide but continues as a defined nerve fiber from the cell outward. This is believed to be the origin of the motor nerves. The above beliefs, however, as yet need substantiation in discovery.

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[1] The Brain and its Functions, International Scientific Series.

Midway in the cerebral organ, occupying the center of the hemisphere, are two oval-shaped bodies, known respectively as the optic thalamus and the corpus striatum. Each is composed of several ganglia, the first being connected by nerve fibers with the posterior, the second with the anterior portion of the spinal chord. These, according to the hypothesis of M. Luys, are intermediate stations for the nerve currents. All the sensory nerves of the body are gathered into the ganglia of the optic thalamus, from which they are again distributed to the cerebral lobes. The return nerves from these lobes are, on the contrary, gathered into the corpus striatum, from which they are distributed to the muscles of the body. It is not necessary to give the somewhat questionable conclusions which he draws from this mechanism of the cerebral nerve system.

If now we trace the nervous system downward through the different classes of the animal kingdom, its complexity of organization is found to gradually decrease. A head ganglion, sending off nerves to the organs of special sense, is found to exist in the arthropods and the higher mollusks and annelids, but it has lost the distinctive features of the vertebrate brain. There is no longer a separate cerebral organ above, and only connected by fibers with, the ganglia which directly receive sensation and control motion. Only the analogue of the basal vertebrate brain seems to exist in these lower animals. In the Vertebrata the cerebrum may be removed without detriment to the functions of animal life, and possibly without entire removal of consciousness. In this condition a vertebrate animal may be in nervous analogy with the normal condition of the lower animals mentioned, though from lack of dependence on its lower head ganglia, in the normal state, these possess no specialized powers of consciousness.

At a still lower level in the animal world all clear indication of nervous centralization disappears. Ganglia still exist but perhaps only as agents to draft off the sensory currents of energy to the various muscles. There probably exists a vague consciousness, but no condition that can be called psychical. The nerve system in these creatures has sunk to the level of the sympathetic in man. Still lower every trace of a nervous system vanishes, though probably continuous lines of cell protoplasm yet exist extending generally throughout the body. This condition can be traced down into vegetable life, and particularly into the Algæ, whose generalized cell substance and lack of indurated covering renders every portion of them subject to the inflow of external energy. The fibril of the cell thus seems to be the germ of the nerve apparatus of the fully developed animal.

It may be noted in conclusion that in the hypothesis of nerve development here advanced is avoided the necessity of the long and intricate explanation of nerve genesis offered by Herbert Spencer. In this view the nerve fibril is a constituent part of every cell, and the nerve and muscle function of conduction and contraction is performed by the Protozoa. In all animals of the many-celled character the protoplasmic connection between the cells functions as the primitive nerve fiber, and each cell as a primitive ganglion. Nothing further than development of this primordial apparatus is requisite as the animal race develops. And even in the most highly developed nervous system the line of its phylogeny is evident in the mode of formation of the fiber, and the character of its connection with the ganglion cell. All that is further requisite is conductive specialization, the restriction of each special impression to a special line of conduction. And natural selection has doubtless been the agent in producing this effect.

(To be continued.)

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EDITORS' TABLE.

EDITORS: A. S. PACKARD AND E. D. COPE.

—— The cultivation of pure science is most successful when pursued from non-utilitarian motives. In persons who cultivate it in this way it has a sentimental as well as an intellectual origin.